King County Regional Infiltration/Inflow Control Program
Local Agency Workshop #3 - Summary
Tuesday, July 18, 2000

Local Agency Workshop #3 was held Tuesday, July 18, 2000 at the Bellevue Inn in Bellevue, Washington. Participants included representatives from the cities and sewer/water districts within King County and that portion of Snohomish County that discharge wastewater to the King County system. The participants were organized into nine regional roundtable groups with their assigned local area manager (LAM) from the consultant team at their table.

Workshop Purpose
This workshop was the third of four workshops planned for the year 2000 for the Infiltration/Inflow (I/I) Control Program. Building on the work completed at Workshops #1 and #2, Workshop #3 was largely designed to present technical concepts that are part of the Program and to allow the Local Agencies to pose questions related to these concepts.

The major emphasis of Workshop #3 was on technical, engineering components of the overall Program. Topics included:

- Pilot Basin/Project Candidates (Current Local Agency Knowledge)
- Pilot Basin/Project Selection Criteria
- Flow Monitoring/Data Development Process
- Infiltration/Inflow Modeling Applications
- Infiltration/Inflow Assessment Protocols
- Supplemental Federal Funding for Additional Pilot Projects
- Post-Workshop Briefing on CALAMAR, a French system for determining rainfall

The flow monitoring and data development section focused on relatively standard techniques and methodologies, while the modeling and protocols sections were intended to provide participants with a conceptual approach on how the modeling and protocols will be used and applied. The concepts described in these two sections will be developed in greater detail over the next several months to reflect issues and concerns that were expressed by the Local Agencies.

Welcome and Introductions
- Gunars Sreibers, Regional I/I Control Program Manager, welcomed the attendees and explained that the workshop format would be similar to the first workshop, with small group discussions.
- Dave Christensen, Chair, Metropolitan Water Pollution Abatement Advisory Committee, also welcomed participants to this technical workshop.
- The key elements of the workshop's content were viewed in a PowerPoint presentation. A handout of the presentation was provided to attendees at the workshop. The following notes summarize the speakers' explanations of these key elements and should be read in conjunction with the PowerPoint presentation handout.

Program Update
Mr. Sreibers presented a Program update. He noted that approximately 800 flow monitors would be in place by November, including the 75 already in the ground. He noted that 40 pilot basins/project candidates have been submitted by Local Agencies to date, and he invited more submissions from the Local Agencies. He then explained that there would be an effort to leverage federal funding for more pilot projects in 2002; he pointed out that letters of support from Local Agencies would enhance the chances of receiving funding. He indicated that the November workshop would be geared toward policy issues, and he encouraged participants to urge their policy people to attend that workshop.

Workshop Overview and Reporting Out: Pilot Basin/Project Criteria and Candidates Status Report
Alice Shorett, Deputy Program Manager, Public Policy/Consensus, Earth Tech Team, outlined the objectives and process for the workshop. She indicated there would be a five-minute roundtable discussion following each of the three technical presentations, during which the workshop participants could compile their questions. She encouraged participants to write down all questions as they arose and indicated that they would have a chance to pose their questions to a panel at the end of the third presentation.

Ms. Shorett reviewed the pilot basin/project selection criteria that had been finalized at the end of Workshop #2. She indicated that the Local Agency input at that workshop had resulted in substantial changes to the draft selection criteria and that these changes had been incorporated in the Decision Document that was sent out after Workshop #2.

Mr. Sreibers reported on the status of candidate pilot basins/projects. He said he expected the list of candidates to grow over the winter, resulting in potentially hundreds of pilot basins/projects being submitted for consideration. He reminded Local Agencies that they are needed to help identify egregious I/I problems and that King County's goal is to provide an opportunity to improve the I/I situation in the entire region.

Flow Monitoring/Data Development Process
Pat Stevens, Earth Tech Team, presented the technology and methods for measuring flow in sewers and also described how the data will be reported. He noted that this program represents the largest installment of simultaneous flow meters in the US, and probably the world.

He defined the two types of I/I that this program will focus on: Rain Dependent Infiltration and Inflow (RDII) and Base Infiltration. RDII refers to clear water that enters the sewer system immediately and up to three days after a rain event. Base Infiltration is clear water that enters the sewer system on a steadier basis; it changes over weeks and months rather than immediately after a storm event. Base Infiltration occurs when ground water rises above a sewer line or when a sewer line drains hilly land. He described the strategies for measuring RDII and estimating Base Infiltration. He explained that the entire regional sewer system would be broken down into 22,000 linear foot mini-basins to allow more exact measurements of I/I levels within those basins.

He described the installation and workings of the depth and velocity sensors on the flow meters. He also described hydraulic impediments that can inhibit uniform flow within the system and how the impediments can complicate the accurate measurement of depth and velocity. These impediments are noted during initial site investigations. At that time, each site is rated (A, B, C, or D, with A being the best rating) according to the reduction in uniformity caused by the impediments. "D" sites are not accepted for metering unless no other metering points are available. Flow meters are initially calibrated at the site when installed and a series of manual depth and velocity measurements are conducted during the project to achieve statistical confidence in the meter's accuracy. The series of manual confirmations may result in minor adjustments to calculated flow data at the end of the project. All data that are produced during the project are considered preliminary; data are final only in the final report.

Infiltration/Inflow Modeling Applications

Jim Peterson and Tom MacBriar, Earth Tech Team, presented the proposed methodology for developing regional I/I impacts. They described the modeling tools that will be used to estimate 20-year peak I/I flow impacts based on measured short-term precipitation and flow data collected during the 2000/2001 wet season. Mr. Peterson showed the breakdown of the County system into 75 long-term basins and the breakdown of those long-term basins into 150 model basins. Each model basin will include from two to thirteen mini-basins containing an average of 22,000 linear feet of sewer. King County will select PC-based model software in August that will use new I/I Program precipitation and flow data as well as existing King County data. It will be used to develop model basin hydrographs that will feed into a hydraulic model of the King County conveyance system. Each basin model will simulate projected I/I flow under various wet weather conditions, both prior to and following any proposed I/I reduction. The basin models will address different types of infiltration and inflow, including direct inflow, groundwater infiltration, trench infiltration, and pervious inflow. The basin models will be calibrated using measured flows and accumulated knowledge of particular basin conditions to match simulated flow to measured flow. The modeling process will also include the creation and calibration of a sewer system conveyance model. The conveyance model will be used to estimate the I/I reduction impacts that alternative basin rehabilitation options would have on the conveyance system and treatment capacity requirements and to help direct priorities for future I/I improvements.

Infiltration/Inflow Assessment Protocols

Barry Scott, Deputy Program Manager, Local Agency Engineering, Earth Tech Team, described I/I Assessment Protocols that are to be developed, including the following:

- How to identify excessive I/I from mini-basin flow data
- How to identify sources and severity of I/I and needed repairs
- Approaches to estimate the cost of I/I repairs
- Approaches to determine rehabilitation efficiency, including estimating the benefits of I/I removal (cost savings, rate impacts, environmental and public health benefits)
- Approaches to determine the cost benefits of an I/I Control Program

Alice Shorett asked the participants to consider, during a 20-minute table discussion, what questions they wanted to pose and whether or not the flow monitoring approach seemed right.

She also asked the participants to consider whether or not the modeling and assessment protocols approaches were on the right track at this point in their development.

Panel Responses to Questions from Tables
(Where possible, the table from which the question originated and the responding panel member is identified.)

Flow Monitoring, *Pat Stevens*
Q**: (***East 1*) How do you distinguish between two areas in determining Base Infiltration?
R: The most valid way to determine Base Infiltration is to measure the water piped into a neighborhood and to subtract it from the water leaving in the sewer. The difference is Base Infiltration. This process is difficult; most agencies do not want to follow this rigorous approach and prefer some type of estimate. Therefore, a modified "Stevens-Schutzbach" method will be used to estimate Base Infiltration. An explanation of the method is included on the June 2000 Flow Monitoring Report CD from the County.

Q: How do you make valid interpretations of Base Infiltration?
R: Users should be aware that these Base Infiltration numbers are estimates and are not suitable for rigorous calculation or design purposes. This is an empirical method for estimating Base Infiltration and there are several situations that make the method highly uncertain. For example, pump stations can cause wide variations in flow results and make Base Infiltration hard to determine. However, in basins with normal diurnal flow patterns, estimating Base Infiltration provides accuracy to within 20% or so, making the effort worthwhile.

Q: How are we going to look at the flow monitoring data and make refinements?
R: The technical team has substantial experience in evaluating flow data. It is expected that review of the data by the technical team and the Local Agencies will result in more accurate measurements.

Q**:** How often are data being downloaded from flow monitors?
R: Field crews visit each site weekly to collect data and assure proper operation of the meter. We are using a new scatter graph technique to allow the field crews to very quickly determine if the meter is working correctly. Weekly visits reduce the maximum down time of a meter to one week. Long-term meter data collection is accomplished by computer, making data collection available more frequently, if needed.

Q**:** What about blockage/build-up in the meter?
R: It's relatively rare since the depth sensor is located out of the flow at the top of the pipe; only the velocity sensor, about the size of a ½ inch matchbook, is in the flow.

Q: (*North 1*) Is there accounting for side sewers?
R: No, only public sewers were considered in determining the size of mini-basins. However, any judgments we make on the severity of RDII must take into account the existence and number of side sewers.

R: *Ed Pier, Earth Tech Team,* noted that the point of meeting with Local Agencies is to identify those types of situations, so that the information can be taken into account when choosing mini-basins.

Q: (*East 2*) What if you are measuring dry weather average flow when someone opens fire hydrants for flushing?
R: This type of situation will only be a problem if it is raining when the flushing is done. If it is not raining, then the excess flow will stand out as an aberration in the normal hydrograph for the basin being measured. It would be very helpful for Local Agencies to inform us when they flush.

Q: (*North 2*) What about waterline flushing/sewer cleaning?
R: Usually, there are approximately 1500 gallons of water associated with sewer flushing/cleaning, which is not a significant impact on the system. If it is a more significant sewer cleaning flow, such as purposeful inflow from a water body source that occurs for one hour every Tuesday, we will spot it. If such flushing occurs during rain events only, the volume of flushing water will be considered RDII. Again, Local Agencies should inform us if they conduct this type of activity.

Q: (*South 1*) Could you explain the difference in the units used for measurement?
R: Gallons per day per linear foot (gpd/lf) is the most dependable since we have good data for sewer length for all mini-basins.
Gallons per acre per day (GPAD) is easier because the computer tells acreage. The problem with it is that the calculated numbers are skewed by the density of housing developments and the presence of open areas, such as sports fields, ravines and parkland.
Gallons per day per inch mile diameter (GPD/In-mi.) will normalize a mini-basin by the footprint of the pipe in the system. This type of measurement necessitates that we know the diameter of the pipes and that we generate inch-mile numbers, which is hard to do by hand.

Q: (*North 2*) What about measuring flow in mini-basins where flow in the pipes is only at a depth of 0-2"?
R: It's difficult to do. If a flow meter is wrong, it is almost always because of the depth measurement. Velocity becomes an issue with small diameter pipes that can get clogged. In cases where the flow is too shallow for independent depth and velocity calibrations and confirmations, we will typically use a snap-in weir to verify the meter's calculated flow rate.

Q: What is the minimum depth of flow that meters will detect?
R: Approximately ½ inch; however, our specification is one inch. In small basins that have little I/I, it is common for the flow in the middle of the night to be too shallow to measure and we see a gap in the data. Although it is disturbing to see the gap, we know that we do not have an I/I problem.

Q: (*South 2*) How are early data affected by meter calibration?
R: The most common cause of bias in flow data is a depth bias that results from flow waves or pump station surges. In such cases the depth target is continually moving, and the bias may be discovered only after several manual measurements. Usually such bias is a fraction of an inch.

Q: When each calibration adjustment is made, how are the Local Agencies informed? Will there be a weekly report?
R: If an adjustment is made, it is usually done once at the end of the metering period. There is no routine reporting of the adjustment, but the information is always logged and available.

Q: How are flow data discrepancies resolved?
R: Discrepancy between any two measuring devices is the rule, not the exception. We identify discrepancies through "flow balancing" where several upstream meters are compared to a downstream meter. There should always be a difference and we determine if the difference is reasonable based on the wastewater contribution expected from the intermediate contributing system.

Q: How do the Local Agencies get information related to flow monitoring?
R: The best thing to do is have someone in each Local Agency learn how to read the scatter graphs. Please contact Pat Stevens at (206) 762-5070 if you want directions on how to do this. Review of the scatter graphs will allow you to verify what has been done and confirm that the data are correct.

Q: (*North 2*) Why distinguish between data collected on weekdays and weekends?
R: Suppose there were storms at noon, once on a Thursday and once on a Saturday, that resulted in a sewer flow of 11 million gallons. How much RDII occurred? Let's assume that on Thursday, the RDII was 2.6 mgd while on Saturday the RDII was 3.0 mgd, which would be a 10% error. Considering the difference in normal sewer flows that we sometimes see between weekday and weekend flow patterns, RDII measurement errors of up to 50% can occur.

Q: How do you determine the variation of the certainty of your data when using different quality sites? That is, does an "A" site need more analysis than a "C" site?
R: The most common problem with a "C" site happens when there is a downstream/upstream subtraction of flows. There can be a substantial variation in the resultant RDII calculation when this happens. There must be some engineering judgment to determine unusually large or small RDII calculations when "C" sites are involved.

Q: How are lost data retrieved?
R: The most common loss of data comes from a loss of velocity data, since only the velocity sensor is in the flow exposed to damaging debris. Scatter graph techniques allow us to develop a pipe curve specific to each pipe. As long as depth data exist, the velocity data can be reconstituted by "snapping" it to the specific pipe curve.

Q: If a site does not have data for a wide range of depths, is it appropriate to "snap" the data to the pipe curve?
R: If the data repeat the same shape over a wide range of depths, data can be "snapped" to the pipe curve. If there is a small range of depths or if the pattern is not repeatable, the data cannot be "snapped."

At this point, Ms. Shorett asked the participants whether this approach for flow monitoring was understandable and acceptable. The participants signaled their agreement. Panel questions related to modeling then followed.

Flow Modeling, *Jim Peterson and Tom MacBriar*
Q: What if there is constant I/I?
R: Constant I/I is somewhat unusual. It would be likely that most of the I/I in this case would be due to infiltration or water from groundwater that flows at a constant rate.

Q: How can the model adequately project 20-year flow conditions from one to two years of data? How are storms and soil conditions considered? What if we don't get any storms since storm overflows may not occur in a short storm?
R: The nomenclature for timeframes can be somewhat misleading. A 20-year flow actually refers to a magnitude of flow that has a 2% probability of occurring or to a flow that would be expected to occur once every 20 years. We are hoping we will be able to capture several 20-year or greater flow events during the monitoring period. The model will be calibrated to whatever flow events we are able to capture. Ideally, we will be able to calibrate the model to flows caused by several small storm events as well as several medium and large events. Once calibrated, the model will be run using 50 years of precipitation data (collected by the County) to generate a pool of flow data points. The 20-year flow event will be statistically derived from this pool of data points. If there are insufficient large storm events, the derived 20-year flows will be less reliable and the results will be so noted and applied with the lower reliability in mind. In such a case, additional monitoring may be recommended to verify the projected flows. In the meantime, projections may be applied to approximate I/I impacts, reductions and rehabilitation measures.

Influence of site conditions (e.g. soil conditions) and unique basin characteristics will be accounted for in the calibration process when the four components of I/I are adjusted to match the measured wet-weather hydrograph for that mini-basin. Obviously, the calibration will be more reliable if it can be done against low, medium, and high measured events that bracket the desired 20-year flow event. If no storms occur, then additional monitoring would be recommended.

Q: Are model basins or mini-basins going to be compared?
R: Model basins will be used for direct comparison. Mini-basins may be ranked based on their relative I/I flow per linear foot of sewer versus the rainfall amount.

Q: How are County data being used, and how do recent developments, such as growth, affect the data, and how are these developments incorporated?
R: It is not yet certain how much County data apply directly to the Local Agencies. It appears that precipitation data collected at Sea-Tac Airport and various gauges throughout the County may be applicable. This will be verified when the modeling process is initially tested. Growth will be considered in establishing base wastewater flows.

Q: Is model selection holding back the process?
R: No, we are on schedule. We do not yet have the software, but the general approach is in place. The software being selected and the conversion of data into our model will enable the

Local Agencies to make their own interpretations of the data. We are trying to make the data universally accessible. Mr. Sreibers indicated that data sharing would happen as much as possible.

Q: How small of a storm will be accepted?
R: It is the flow recurrence interval that is important. A variety of rainfall conditions over given basin characteristics can produce the desired flow event.

Ms. Shorett indicated that the next question and answer session would be focused on I/I Assessment Protocols and would include theoretical information on costs and benefits of I/I control.

I/I Assessment Protocols, *Barry Scott*
Q: Have you accounted for future costs to keep I/I out of the system in the RWSP?
R: The RWSP accounted for no I/I removal. It assumed a 7% degradation of the system every ten years. So, while we are staging improvements, we still need to assume a 7% degradation of the system every decade.

Q: How will non-cost criteria be addressed?
R: Political and environmental issues are expected to come into play once the data are in and have been evaluated. As shown in the cost-benefit analysis (see "Cost Benefit Determination" Graph, p. 33 of PowerPoint presentation), the area above the curve between "Optimal Removal" and "Break-Even" point would be an area for discussion.

Q: What unit costs are available from RWSP/CSI?
R: CSI costs are related to pipe projects, not to I/I, so we are going to be developing new costs related to I/I rehabilitation. The RWSP provided some planning level costs for a variety of system improvements, from pipeline to pump stations and treatment plant expansion.

Q: Will the development of unit cost factors involve pilot projects?
R: Yes. A primary purpose of the pilot projects is to establish unit costs for application in development of Program costs.

Q: (*North 2*) Will mini-basins be ranked altogether or separated by region?
R: We will look at a plot for each mini-basin, rank all mini-basins, and give Local Agencies a breakdown of their own measurements. We will also look at major hydraulic basins. We will rank the "worst to best" basin for the entire region and the "worst to best" by Local Agency.

Q: What is the accuracy of the cost-benefit analysis?
R: This is a planning level effort, so the level of accuracy will be at an appropriate level for this purpose.

Q: (*South 1*) Won't it be difficult to compare the costs and benefits, looking at the design life of a manhole versus the design life for regional conveyance?
R: That is correct. Until we have done all the work, we won't know what repairs we will need. The costs are based on standards and will be blended together for a cost range to be weighed against the benefits.

Q: How do you determine the rating for severity of RDII?
R: The methodology is still being developed, but in general we will look for breakpoints in the severity rates derived from the ratio of mini-basin flow to rainfall slopes.

Supplemental I/I Funding
Marcos Lopez, Program Manager, Public Policy/Consensus, Earth Tech Team, then presented information on the process for applying for supplemental federal I/I funding for the I/I Control Program, under Congressional line item funding. He explained that this federal funding proposal was very recently presented to the Regional Water Quality Committee, which officially supported applying for such supplemental funding. He pointed out that what would help this Program acquire federal funding is the fact that such funding is to be earmarked for pilot projects that will benefit the 34 Local Agencies.

Mr. Lopez noted that one of the potential impacts of obtaining federal funds could be that the overall I/I Control Program, or additional pilot projects, would be subject to federal mandates that would increase the permit process and might extend the Program timeline.

Mr. Lopez explained that the County would apply for a $37 million grant from the EPA's FY 2002 State and Tribal Assistance Grant (STAG) Account. This funding source needs a 45% local match. King County intends the $31 million it has already dedicated to the I/I Control Program to be the local match. The $37 million would provide funding for an estimated 25 additional pilot projects as well as additional sewer system evaluation surveys (SSES) and longer time periods for flow monitoring measurements.

Mr. Lopez expressed the hope that the Local Agency policy boards and commissions would support the effort to obtain this federal funding by submitting letters of support to King County. He pointed out that this support would be the key to obtaining federal funding. The letters need to be submitted by the end of August or early September. The County will submit the application at the first of the year for FY 2002 (starts October 1, 2001). The County should be notified by May 2001 whether or not funding can be expected. This schedule should allow additional pilot projects to be incorporated into the process. Mr. Lopez again offered assistance from the consultant team to present this idea to Local Agency boards and governing bodies. He said that the Earth Tech Policy Team would be available to brief these groups.

Wrap-up and Next Action Steps
Ms. Shorett summarized the work that had been done at Workshop #3 as follows:

1. Workshop participants were briefed on the pilot basin/project selection criteria;
2. The flow monitoring/data development process was explained and questions related to this area were answered;
3. I/I modeling at its current point of development was explained and questions were responded to related to model development and use;
4. I/I assessment protocols were explained and questions responded to; and
5. The I/I Control Program supplemental federal funding was explained, with a request for letters of support from the Local Agencies.

She indicated that the next steps included the LAMs continuing to work with their Local Agencies to determine the most appropriate potential pilot basins/projects for consideration by the larger group and the need for letters of support for federal funding.

The next half-day workshop (Workshop #4) will be held Thursday, November 16, 2000. (This workshop has been moved from November 8th.) The Workshop will focus on policy issues related to I/I Control Program financial impacts and benefits, among other discussion topics. Local Agency policy representatives are encouraged to attend Workshop #4 because of the policy topics that will be discussed.

Post-Workshop Briefing on the CALAMAR System

Pat Stevens, Earth Tech Team, discussed the details of the CALAMAR system, a French rainfall measurement system, and answered questions. Pat handed out a worksheet that detailed the system and how it would work. If you are interested in receiving this packet of information, please contact Mr. Stevens at (206) 762-5070.

The CALAMAR system is used to quantify rainfall between existing rain gauges. It will be used to define how much rainfall occurs within the different basins. CALAMAR combines the County's existing network of rain gauges with the National Weather Service NEXRAD radar to provide over 1,100 rainfall measurements within the sewer service area. The system calibrates and processes the NEXRAD data in a unique, patented way that produces rainfall measurements with a typical accuracy of +/- 10%. CALAMAR has been selected for use in the King County Regional I/I Control Program because it provides more accuracy than is available from raw radar data or from rain gauges alone. The briefing provided a basic understanding of how CALAMAR uses the rain gauge network to calibrate the radar images and how rainfall data are produced.